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SENTENCE MEMORY: A METHODOLOGICAL AND THEORETICAL EVALUATION OF THE HAM MODEL

by

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ABSTRACT

It was noted that a study reported by Anderson and Bower (1973), intended to explore the nature of memory for sentences, did not provide data consistent with predictions generated from their HAM model. Two explanations to account for the discrepancies between their predictions and their data were offered. Either their theory was in error, or the data was artifactual due to a number of methodological flaws in their experimental procedure. An experiment, designed to correct these methodological difficulties, yielded results which were in close agreement with those of the Anderson and Bower study. It was concluded that the discrepancies were due to the inadequacy of the HAM model to account for the phenomenon under investigation. An alternate explanation, hypothesizing an image construction process, was outlined.

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INTRODUCTION

The present state of the art in psycholinguistic research presents a broad range of interests upon which a discussion can be based; emphasis ranges from the purely formal theory to an almost atheoretical brand of empiricism. Although not intended to be exhaustive, the following taxonomy of psycholinguistic concerns will help focus attention on the topics relevant to this thesis.

At the one extreme are the theories developed within the context of artificial intelligence. (Schank, 1972; Schank and Colby, 1974) Up to this point in time such individuals have not made any attempt at deriving psychologically relevant theories from their formalisms. Neither have such theories been extensively exploited for the empirical implications they might have. (But see Thorndyke, 1975) The influence of these theories on psychology has been primarily of a conceptual sort, helping to popularize such notions as 'propositional structure of knowledge'.

Closer to the substantive domain of psychology are a few recent attempts at global theory construction. These theories, although attempting to address traditional psychological problems and to provide answers in the best empirical tradition, indulge in an extensive importation of concepts and formalisms from other disciplines. For example, the theory proposed by the LNR research group (Rumelhart,

Lindsay, and Norman, 1972; Norman and Rumelhart, 1975) incorporates a Fillmore case grammar notion, and utilizes formalisms quite similar to those of Schank. Anderson and Bower (1973) propose a theory which appears to be a unique admixture of phrase structure grammar sprinkled with a few case grammar notions all within the context of traditional work in associative memory theory.

The more conventional empirical explorations within the area present a somewhat more bewildering array of concerns. On the one hand there are those researches which are intended to explore and expand a theory of a specific and restricted aspect of human functioning; an example would be the notion of levels of linguistic processing suggested by Craik and Lockhart (1972). In a somewhat more restricted vein are those researches which attempt to demonstrate some specific theoretical orientation; two examples of this approach would be the series of studies which developed from Quillian's (1968) theoretical presentation (see Collins & Loftus (1975) for a listing of these studies), and the series of studies which followed up on the original Bransford and Franks (1971) experiment. On the other hand there are those studies which may offer interesting demonstrations of empirical regularities but which are almost totally lacking in theoretical direction (Tulving and Madigan, 1970).

Most (if not all) recent research in the general area of language has its roots in a welter of issues raised by

Chomsky's attempts (1957, 1965) to formally describe language in terms of an emphasis on syntax. Criticisms of his theory have centered on the inadequate treatment it gives to the semantic side of language. The counterclaim has been that humans base their processing of linguistic material on the semantic interrelations of the meaning bearing components of the language. Under this view the so-called structural representation of linguistic knowledge is not a syntactic tree structure with its compendium of transformations but rather a network (somehow conceived) of semantic interrelationships (e.g., Quillian, 1968.).

This development was taken one step further by Schank. The semantic network is now talked about in terms of propositional structures. In fact, the phenomenon which is now being modelled is not semantic representations but rather the conceptual or ideational store of human knowledge which is assumed to underlie not only linguistic structures but presumably all aspects of human behavior involved in the utilization of stored information. It is at this juncture that the up to now language oriented theories meet the traditional memory theories head on, since this conception of a conceptual network resembles the standard notion of long term memory.

There are at least two major historical traditions in the work on human memory. The one of interest has arisen quite quickly by way of a healthy injection of information processing conceptualizations into the jargon of psychology.

Memory is conceived as a <u>store of information</u>; and with this storehouse are hypothesized various <u>processes</u> which perform such tasks as encoding and retrieving information. Exemplars of this tradition can be found in Kleinmuntz (1967) and Norman (1970). It was natural for these theorists, already working within a computer information processing metaphor, to remain sensitive to developments in artificial intelligence. Thus, a Schank-type theory of conceptual organization developed within the context of language processing could be easily imported into a theoretical conception of memory viewed as a store of information.

This cross-fertilization of ideas from three distinct disciplines has given rise to a few problems, however. In the merging of theoretical perspectives there has been a tendency to ignore various process details of human performance, specifically in the context of human memory. Fillenbaum (1973) has observed that most psychological models of human memory up to 1970 are not applicable to the substantive problems of the psycholinguist. The memory theorist has generally been concerned with how information is acquired and retrieved, and in specifying those environmental factors which aid or inhibit these processes. Little attention had been given to the nature of the structural representation of specific classes of input -- in this case, linguistic material.

As outlined above, there has been a significant reversal of interest in some quarters since 1970.

Theoretical attention is now being focussed on the form in which knowledge is retained in memory. The difficulty here, however, is that these theories have arisen largely from a context which addresses specific linguistic issues, and so the problems associated with memory processes have been ignored. This, from a purely theoretical perspective is not overly serious since it merely amounts to an error of omission. Given time, a more complete integration of theoretical perspectives will no doubt be achieved. There are a few methodological problems of immediate concern which can be best appreciated if a distinction between two broad theoretical issues is clearly made.

Kintsch (1970) has already made the point that in single word memory experiments it is not the word which is stored, but some indication that the word has been presented in the experimental situation. The word itself (or more accurately, the word's meaning) is already <u>in</u> memory. A similar rationale can be made for experiments using sentences as stimuli. The individual word meanings are already in memory; the sentence itself (as stimulus) indicates a particular set of relationships among the words.

According to this analysis it would follow that the desideratum for a <u>theory of knowledge</u> would be a representation which not only specifies all the possible relations which a particular 'idea' is <u>capable</u> of entering into, but also the classes of other 'ideas' which it is <u>capable</u> of being related to. For example, it would not only

have to specify what a <u>nurse</u> is -- human, works in hospitals, etc. -- and the sorts of actions a nurse can engage in, either in the role of nurse -- assisting in surgery -- or more generally as a human -- eating a meal -- but the theory would also have to specify the things which can be eaten -- fruit are edible but a gold necklace is not. A <u>theory of sentence memory</u> (or of any other meaningful material) will then involve the explanation of how a sentence specifies a subclass of the above knowledge. The task of elaborating the nature of what is involved in this 'specification' is the primary substantive addition which sentence memory makes to a more general theory of knowledge. Observe, then, that although one can probably construct a theory of knowledge independent of other considerations, within the present context a theory of sentence memory involves postulating an underlying knowledge structure.

Given this understanding, one can now appreciate the sorts of methodological problems which presently exist in the area. Largely because the above theoretical distinction is not made, the use of linguistic material in a memory task paradigm has generally and uncritically been assumed to adequately provide data which bear upon the nature of the underlying structure of interest, i.e., either the structure of knowledge or the structure of the memory for the particular input (Fillenbaum, 1970, 1973). In reviewing the relevant literature on memory for linguistic material Fillenbaum (1973) concludes that "such data provide

information *simultaneously* about possible underlying structures *and* about memorial and retrieval (or perhaps reconstructive) processes (p.6)".

The point is that in not acknowledging the *memory* aspect of sentence memory, researchers have not adequately controlled for the process effects of memory in their experiments, making the data difficult to interpret. (It is interesting to compare this view with that of Jenkins (1974) where he suggests that methodological problems arise if one tries to treat *memory* independent of, say, language or inference processes.) Some of these methodological difficulties will be discussed in the following section. Anderson and Bower's (hereafter abbreviated A&B) theory and one of their experiments in particular will be analyzed in some depth in an attempt to illustrate both the necessity for the above theoretical distinction and the resulting implications it has for methodology.

The HAM model and sentence memory

The experiment of interest for this thesis is the first one reported in chapter ten of A&B (1973). The basic paradigm was a short-term memory cued recall study. *Ss* were presented with a list of sentences, each sentence containing four 'content' words, an agent -- abbreviated A -- an object (O), a verb (V), and a location (L). All sentences were of the form 'In the *L* the *A* *V*ed the *O*'. After a pair of study trials a test trial immediately followed where three of the

four content words were deleted from each sentence. The task of the <u>Ss</u> was to attempt to recall the missing content words.

In running the experiment in question their working premise has been that "contingencies in recall of sentential elements reflect proximities of the elements in the underlying mnemonic representation of the sentence (p.283)". What this implies in terms of generating predictions from their graph structure representation of the sentence form L.A.V.O is as follows: O and V should elicit each other more often than either elicits A or L. Similarly, A and L should elicit each other more often than either elicits O or V.

In examining their results one can see that these expectations are not very well met in the data. Although there are isolated instances of matching between data and theory -- for example, A elicits L more often than any other word, and V maximally elicits O -- there are even more instances of significant discrepancies. Examples of these are: A elicits O as often as it elicits L; there is a high reciprocal elicitation of O with L even though these content words are farthest apart in the graph representation.

There are at least two explanations for these and any other discrepancies which exists between A&B's data and the predictions of the HAM model. The first explanation involves elaborating on what seems to be a theoretical confusion over exactly what HAM is supposedly modeling and thus what the data is intended to support. In chapter seven, entitled "The

Structure of Knowledge", A&B announce that "the most fundamental problem confronting cognitive psychology today is how to represent theoretically the knowledge that a person has (p.151)". The HAM model was developed to address this problem, and was intended to "provide a common currency in terms of which <u>linguistic</u> <u>and</u> <u>perceptual</u> information could be brought together to be compared, modified, combined, and coordinated in usage (p.152, emphasis added)".

Yet in presenting the above probed recall experiment they are addressing the specific problem of sentence memory. As previously noted, this will demand the consideration of the effect of process details of the phenomenon, not merely within the context of developing a theory, but more importantly in the context of designing a methodologically sound experiment. A number of studies suggest that syntax plays an important role at the encoding level of sentence processing (Sachs, 1967; Bregman & Strasberg, 1968; Wearing, 1971) but that syntactic information is generally lost after this function is served (Begg & Wickelgren, 1974). Although there is a fair bit of evidence to suggest that memory for sentences is semantically based (see Fillenbaum, 1973), syntax can affect what can be recalled (Weisberg, 1971). That is, insofar as details of syntactic structure are incidentally retained in memory for a short period of time, they can emphasize certain ordered relationships among the meaningful elements when verbatim recall is requested. Since it is possible that syntax will be an important determining

factor in what is recalled, an experiment which is intended to test a specific model of sentence memory should control for this possibility.

The main design modification of A&B's experiment will be the addition of three syntactic forms for sentences used in the experiment. Some research (Hornby,1972; James, 1972; Olson & Filby, 1972; Perfetti, 1973) suggests that a change of voice will affect the nature of what is recalled. However, the rationale has generally stemmed from the 'topic-comment' distinction. Although this distinction seems reasonable within a connected discourse context, it does not seem appropriate in situations where single sentences are used as stimuli. Nonetheless, the sentences in the present study will be of active or passive voice, even though specific predictions regarding their possible differential effect on recall are difficult to make.

In line with the above discussion, the linkage between O and L would be real but would have relatively little to do with an 'underlying' knowledge structure. Since it is possible that the O-L linkage is due to, say, characteristics of the input, then a modification of syntax which affects the locative would seem warranted. All of A&B's sentences were of active voice with the prepositional phrase (i.e., the Location) having wide scope. In addition to the voice changes, the sentences in the present study will differ in the scope of the prepositional phrase. A sentence will be of <u>wide</u> scope if the Location modifies the

entire A.V.O proposition. A sentence will be of narrow scope if the Location modifies a specific noun. In this study the first noun of the sentence will be so modified: in active sentences the form would be A.L.V.O; in passive sentences the form would be O.L.V.A. [1] (See Appendix B, criterion 1 for examples of the syntactic forms used in the present study)

The other explanation would be that A&B's results are totally artifactual, and thus under more rigorous experimental conditions the data would not be replicated. Three aspects of A&B's procedure -- their choice of instructions, their manner of constructing stimuli, and their choice of a dependent measure -- make this explanation fairly likely. The problems with each of these procedures will be discussed in turn along with how they will be modified for the present study.

The first problem involves the nature of the instructions to the Ss which A&B employed. As they described it, "the exact nature of the experiment and the types of recall cues were described in considerable detail to the subjects (p.296)". Studies involving orienting tasks (e.g., Hyde & Jenkins, 1973; Graesser II & Mandler, 1975) show that a subject is capable of recalling various characteristics of

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1 Sentences where the Location follows the second noun, i.e., A.V.O.L or O.V.A.L were not used because two possible phrase structures can be generated for each of these sentences. This would make the data collected from them ambiguous in their significance.

linguistic input dependent on what he is set to attend to. Assuming that demand characteristics were built into A&B's experiment the most one would want to conclude would be that Ss are capable of performing in the specific way desired by the experimenters. Conclusions regarding what Ss normally do would be rather questionable in their validity. Therefore, in the following experiment the instructions were made as theoretically neutral as possible.

A second problem involved their method of constructing the stimulus material. It may be that A&B would wish to claim that their word class designations (agent, object, verb, or location) would hold for any and all exemplars of each of these categories. However, one does not test this assumption by randomly selecting words from a number of subcategories which exist for each of the content word classes. For example, an agent may be inanimate, human, or liquid. Randomization would simply mask any subcategory differences which might exist. In the present study specific restrictions will be placed on word selection. All agents will be animate-human and all objects will be either animate-human or inanimate. These restrictions are totally arbitrary, and in doing this, generalization of the results to other word classes will of course not be warranted.

Another difficulty arises in their manner of constructing the sentences. It involved randomly combining content words from a word pool. It would be naive to suppose that a sentence could be remembered for only one reason, or

that a word could elicit another word only because of mere proximity in an hypothesized association network. Random combination can result in sentences with unusual characteristics; for example, the semantically anomalous "The hammer in the ocean entertained the peach". It would seem reasonable to discard those sentences which may be remembered for reasons other than the ones the experimenter is primarily interested in. Appendix B provides a complete listing of the criteria employed in the construction of the stimulus material for the present study.

The final modification in A&B's procedure is in the choice of the dependent measure. The measure they chose makes statistical analysis a rather cumbersome task. In fact, their choice of Chi square is particularly uninformative with respect to the questions they were supposedly trying to answer.

It was noticed during the pilot testing for this study that two different scoring measures seemed to be resulting in data patterns which led to different conclusions regarding interword associations. In view of the implications this has for what one is justified in inferring from any one dependent measure, it was decided to score the data obtained in the following experiment in both fashions. A description of both scoring methods employed in this study will be provided in the following section.

METHOD

Subjects

The Ss were 60 University of Alberta students enrolled in an introductory psychology course who participated as part of a course requirement.

Materials

Forty-eight sentences were constructed according to the criteria listed in Appendix B. The sentences were randomly ordered into two lists and photographed, using direct positive film, in each of its syntactic forms. Four sets of slides were thus constructed, each set including all 48 sentences of one and only one syntactic type. The order of the sentences in each set of slides was identical.

For the test phase of the experiment one and only one of the four content words (i.e., agent, object, verb, or location) in each sentence was randomly selected to be the probe for that sentence. For example, with the sentence:

The nurse in the store broke the dish.

the location was assigned the role of probe. The sentence was then typed onto a slip of paper as follows:

The _______ in the store _______ the _______ .

This procedure was followed for each sentence in a list and the test sentences were collated into a test booklet. The sentences in the test booklet were in the same order as those on the stimulus slides. Within each list, every content word was chosen as probe an equal number of times. That is, the agent was probe in six of the sentences, and similarly the object, verb, and location, resulting in a total of 24 sentences per list.

Once a particular content word was chosen as probe for a particular sentence, that word acted as probe in each of the four syntactic forms of the sentence. In the passive sentences, the verb was defined as 'was _verbed_ by', and the entire unit was shown in or deleted from the test sentence as probe assignments required.

Procedure

Subjects were run in groups no larger than five. They were seated in a shallow horseshoe approximately 15 feet away from a screen onto which was projected the stimulus slides. The first list of 24 sentences were shown one at a time for ten seconds; then the list was shown a second time, in the same order, again with an exposure rate of ten seconds per slide. Each _S_ was then given a test booklet, which corresponded to the list just shown, and was allowed twenty seconds per sentence to fill in tne missing words. The _Ss_ were instructed not to turn the page until the _E_

signalled the end of the 20 second interval.[2] When the test booklets were completed they were collected and the second list of stimulus slides were shown. The procedure followed for the learning and test phases of the second run was exactly the same as that for the first run.

Scoring measures

Two methods of scoring the data were employed. These measures are defined as the total number of content words recalled with a given probe, and the total number of times a specific word is itself recalled when each of the other words are used as probes. This distinction can be illustrated as follows

A --> Oa, Va, La

O --> Ao, Vo, Lo

V --> Av, Ov, Lv

L --> Al, Vl, Ol

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2 Throughout the pilot work and the study reported here, it was never necessary to instruct the Ss to turn the page immediately upon the signal to turn. They spontaneously turned the page after finishing a word they were in the process of writing. On two occasions the E quietly reminded Ss who persisted to attempt to recall the deleted words that they should turn the page immediately upon hearing the the signal to turn. On one occasion the E noticed a S turn back several test sentences in the booklet to fill in the missing words of a sentence she had previously been unable to recall. When the test booklets were being collected, the S was asked to indicate the sentence she had recalled out of turn. The sentence was scored as incorrect and she was reminded to not complete the test sentences out of turn.

The upper case letter to the left of the arrow indicates the content word used as a probe while the letters to the right of the arrow denote those words to be recalled. The total recall _elicited_ by A, hereafter referred to as the _probe score_ , would be defined as Oa+Va+La, and similarly for the other probes. The total number of times which A is itself recalled, hereafter referred to as the _recall score_ , would be defined as Ao+Av+Al.

RESULTS

Overview

Six analyses of variance were performed on the data. [3] The mean probe scores and mean recall scores each yielded a 2x2x2x4 split-plot, repeated measures design. The between subject factors included two levels of the scope of the prepositional phrase, and two levels of the voice of the sentence. The within subject factors included two levels of animacy for the object -- either animate or inanimate -- and four levels of the probe word -- either agent, object, verb,

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3 The analysis reported here assumed a fixed population for the content word factor. A separate analysis was performed on the probe data wherein the content word factor was assumed to be a random variable. This analysis did not result in F ratios different from the ones reported here, at least not for the variables of theoretical relevance. The mixed model analysis resulted in a highly significant subject nested within blocks effect, but this simply means that _Ss_ differed in the total amount they recalled, a conclusion which could easily be reached by inspecting the raw scores.

or location.

In addition, separate ANOVAs were performed on each of the individual probe data. Each of these analyses yielded a 2x2x2x3 split plot, repeated measures design. The first three factors are the same as those in the above analyses. The final factor includes three levels of content words capable of being recalled with any given probe word. For example, if the ANOVA was performed on the agent probe data, then the three content words would be object, verb, and location. The fact that the three levels of this factor are different for each probe necessitated the separate analyses.

Main Dependent Measure Results

The ANOVA on the probe score dependent measure -- that is, the average recall elicited by a particular probe -- is summarized in table 1 of Appendix A. The main effect for animacy turned out to be highly significant, with more recall associated with sentences with inanimate objects than with sentences with animate objects. The main effect for probe words was also highly significant. A Neuman-Keuls test of ordered means revealed that the O elicits more recall than any of the other probe words ($p<0.01$). A consideration of the significant animacy X content word interaction (see table 1) will aid in the interpretation of these main effects.

In comparing the differences between sentences with inanimate objects and sentences with animate objects it was

TABLE 1

Animacy x content word interaction for probe data: mean recall elicited with A, O, V, and L as probes.

	A	O	V	L
inanimate	7.90	10.80	9.28	7.38
animate	6.42	7.28	6.40	8.33

found that the O and V in inanimate sentences elicit more recall than their animate counterparts ($p<0.01$). Also, the A in inanimate sentences marginally elicits more recall than its counterpart in animate sentences ($p<0.05$).

Within sentences with animate objects, L elicits more recall than either A, O, or V ($p<0.01$ in each case). No other differences were found in animate sentences.

In sentences with inanimate objects, however, L elicits <u>less</u> recall than O or V ($p<0.01$) and O assumes the place of dominance, eliciting more recall than A, V, or L ($p<0.01$). Also, V elicits more recall than A or L ($p<0.01$).

Basically, then, L shifts from being the significantly <u>most</u> effective probe in animate sentences to being the significantly <u>least</u> effective probe in inanimate sentences. Since the L scores do not differ significantly between animate and inanimate sentences (even though there is a drop in mean recall elicited), it seems reasonable to conclude that the chief reason for the shift in relative

effectiveness of L is due primarily to the high shift in effectiveness of O and V. That is, L is not affected by animacy, whereas O and V are very much so, with inanimacy improving their effectiveness as probes.

The ANOVA on the data obtained using recall score dependent measure -- that is, the number of times a specific word is recalled averaged over the three probe words capable of eliciting it -- is summarized in table 2 of Appendix A. In view of the manner of scoring this measure relative to the probe score, only the content word main effect, plus any interactions with this factor, will show any differences in mean values between the two scores.

A couple of interesting differences between the probe and recall data reveal themselves. In considering the

TABLE 2

Comparison of means of content word main effects for probe and recall data.

	A	O	V	L
probe data	7.16	9.04	7.84	7.85
recall data	8.03	8.37	7.23	8.28

content word main effects (see table 2), a comparison of means reveals that V is <u>recalled</u> less often than any of the other content words ($p<0.01$). In terms of <u>ease of recall</u> A,

O, and L are more or less equivalent. This finding will be best interpreted in a comparison with the probe effectiveness data summarized above, since each set of means suggest an entirely different interword association network.

The dependent measures also differ in terms of the interactions which they reveal. In contrast to the probe data, where a highly significant animacy x content word interaction was obtained, the recall data did not reveal any such interaction. The relative differences in how easily a word can be recalled are not affected by changes in the animacy of the object, even though these changes affect how effective a word will be as a probe.

With syntax interactions, however, the recall data is more informative. Both voice x content word and scope x content word interactions turned out to be significant ($p<0.05$). With probe data voice x content word just reaches statistical significance and so cannot be considered very reliable. The fact that the recall dependent measure is sensitive to syntactic interactions is consistent with the rationale presented in the introduction. However, the results suggest that there now is a problem in determining what the probe scores are measuring.

Apparently without much forethought A&B chose a dependent measure and assumed that it would give data on the particular underlying phenomenon they were interested in. But consider the problem within the context of the present study: if probe scores indicate the 'underlying'

relationship between words, then what do the recall scores -- which are different from the probe scores -- indicate? It may be that both these scores reflect different facets of underlying processing. It is sufficient for the moment to point out that until this problem has been thought through, caution should be exercised in interpreting the results of experiments with these sorts of dependent measures.

For example, there have been a few studies (Clark, 1965; Horowitz and Prytulak, 1969; James, 1972) which have attempted to explore the nature of simple transitive sentences. The general finding has been that the subjects of the sentences are the words most often recalled while verbs are least often recalled. Quite aside from the fact that these findings have not been exactly replicated in this study, one is still left with the observation that when total recall *elicited* is the dependent measure, the object of the sentence is the most effective word, and the probe score for the verb is higher than its recall score. A possible alternate interpretation of what these dependent measures are indicating will be offered in the subsequent section.

Probe Associations

The main incentive for performing ANOVAs on the individual probe word data is to shed some light on specific word associations. These four analyses can be viewed as an attempt to provide additional details of word relationships

to supplement the findings of the first two analyses. In effect, each probe score used in the first ANOVA is partitioned into three components, each component representing one of the content words which can be elicited by the probe in question. The four ANOVAs are summarized in tables 3-6 in Appendix A. The content word main effects,

TABLE 3

Content word main effects for individual probe word ANOVAs: mean recall elicited by A, O, V, and L.

		Probe word			
		A	O	V	L
Recall word	A		2.84	2.45	2.73
	O	2.65		2.88	2.83
	V	2.07	2.86		2.28
	L	2.44	3.33	2.51	

which were highly significant ($p<0.01$) in each analysis, provide data which bear directly on the question of the adequacy of the HAM model. A comparison of means (see table 3) revealed the following word relationships:

i. When A acted as probe it elicited V significantly less often than either L or O ($p<0.01$). Furthermore, it elicited O more often than V or L ($p<0.01$, 0.05 respectively).

ii. When O acted as probe it elicited L significantly more often than A or V ($p<0.01$).

iii. When V acted as probe it elicited O <u>more</u> often than A or L ($p<0.01$).

iv. When L acted as probe it elicited V <u>less</u> often than A or O ($p<0.01$).

These main effects must be interpreted in the light of several significant interactions. Only those results of interpretive relevance will be reported here. (see tables 4-5) All differences mentioned were found to be significant at $p<0.01$.

TABLE 4

Animacy x content word interaction:
mean recall elicited with A as probe.

	O	V	L
inanimate	3.10	2.25	2.55
animate	2.20	1.88	2.33

i) Animacy x content word interactions:

The main effects indicate that both V and A elicit O more often than any other content word. The interactions reveal that this difference is confined to the <u>inanimate</u> O. When O is animate it is <u>not</u> elicited more often than the other content words.

When O is probe it elicits L more often than A or V regardless of the status of O's animacy. The difference is that the inanimate O elicits V more often <u>relative to A and</u>

TABLE 5

Animacy x content word interaction:
mean recall elicited with V as probe.

	A	O	L
inanimate	2.77	3.57	2.95
animate	2.13	2.20	2.07

L than the animate O does.

ii) Syntax x content word interactions:

1. With respect to scope, we can conclude that narrow scope does not induce a preferential elicitation of any content word by O. However, in wide scope O does preferentially elicit L.

2. Both O and V, when used as probe, resulted in a voice x content word interaction.

With V as probe, the elicitation of O is not affected by voice, whereas passive voice improves V's elicitation of A and L.

With O as probe voice does not affect the elicitation of V or L. Passive voice improves the elicitation of A. Whereas in active voice L is elicited significantly more often than A, in passive voice this is no longer the case.

DISCUSSION

The first matter to determine is the extent to which A&B's data have been replicated. The observed event scores numbered 1-28 in table 10.3 (p.303) have been rescored according to the method used in this thesis. Means were computed and were adjusted to facilitate visual comparison of the two sets of data. In selecting the data from the present study, only the means specific to the L.A.V.O sentences were used since sentences of this form were the only ones used by A&B.

TABLE 6

Comparison of A&B's results with those of present study: Mean recall of content words given A, O, V, and L as probes.

	Katzko	A&B		Katzko	A&B
A --> L	2.333	2.27	V --> A	1.5	1.622
A --> V	1.567	1.975	V --> O	2.4	1.939
A --> O	2.3	2.38	V --> L	2.033	1.829
O --> A	2.2	2.244	L --> A	2.467	2.244
O --> V	2.567	2.171	L --> O	2.633	2.39
O --> L	3.3	2.488	L --> V	2.2	2.024

Comparison of the results of both studies are presented in table 6. For our purposes it is sufficient to notice that the relative differences among means is quite similar. This means that the <u>pattern</u> of A&B's data has been replicated. The differences among means taken from the present study are

accentuated, however, which suggests that the methodological changes which were implemented have had the desired effect.[4]

We can conclude that A&B's original data are not purely artifactual. Relations such as the O-L linkage are probably real and so deserve an explanation. Since the HAM model does not account for these data, it is worth considering exactly what the weakness of the model is.

The HAM model

In reconsidering A&B's working premise that "contingencies in recall of sentential elements reflect proximities of the elements in the underlying mnemonic representation" the explanation seems fairly clear. If we keep in mind that this experiment involves short term memory, then within the context of a memory task the reasonable question to ask is: what is involved in the creation of the underlying mnemonic representation? The answer would be equally straightforward: many things are involved, from the specific nature of the input, through encoding strategies, motivational and other biases in information selection, to the underlying store of information which imposes its own sort of order on the input.

From A&B's perspective the underlying mnemonic representation is due to one and only one factor, and that

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4 It may be worth noting that these differences were obtained with 60% fewer subjects.

is the 'structure of knowledge' which HAM supposedly models. The whole purpose of their experiment was to determine if certain theoretical elements bear the close relationship to other theoretical elements which the HAM model expects. The rationale is that dominance in recall of one element over the others, given the fourth as probe, indicates proximity of that element to the probe in the underlying structural representation of the input. This study has shown that one word does preferentially elicit another, but what is damaging to the HAM model as it now stands are those results which indicate that these preferences in elicitation <u>change</u>; they are affected -- in this experiment -- by the nature of the dependent measure, the syntax of the sentence, and the animacy of the object.

Since HAM was apparently developed to model an 'underlying' knowledge structure, no provision was made for details of short term memory processing. When the same model is used to account for the facts of sentence memory, it will necessarily be incomplete. It is rather difficult to imagine how A&B could have overlooked this straightforward distinction between a hypothetical 'underlying' knowledge structure and whatever is involved in sentence memory. It at least seems clear that they were guided by the dubious methodological assumption that memory for sentences gives direct evidence for how knowledge is organized and stored on a long term basis. Following from this assumption it would perhaps be easy to ignore the numerous influences which one

would expect to be manifested in a memory task context.

The status of the HAM model as a theory must now be evaluated. On logical grounds alone it can probably be dismissed as an inadequate theory of conceptual knowledge, but this is of no great concern for the purposes of the thesis. The important methodological conclusion to be drawn from this study is that this paradigm does not seem applicable as a test of a theory of conceptual knowledge organization. The paradigm taps a portion of cognitive processing where many factors are influencing the nature of the response. If it is not impossible, it is at least very difficult at this point to determine what aspects of the response pattern can be taken as indicating the 'underlying' knowledge structure.

Since this paradigm is more suited to exploring short term memory, if HAM is to be at all relevant to an interpretation of the data it will have to be considered to be a theory of sentence memory. It has already been demonstrated that the model does not account for the data. The question is, can HAM be modified to accomodate the data without changing its important features?

One of the characteristics of HAM is the specific relationships among the elements which it defines. How could the model accomodate the changing relationships suggested by the data while still retaining its unique relational characteristics? The most obvious strategy would proceed in the following manner. We first define what may be called a

'prototype' or 'base' structure. This prototype might indicate, for example, the recall contingencies found in simple declarative sentences in the active voice. The HAM model, unaltered, would be such a 'base structure'. Then, associated with this prototype structure are a set of transformations or rules, each of which being in the form: under condition _x_ (e.g., in passive voice) the prototype relations will display some specified new set of relations in short term memory.

Given the complexity of human behavior, this is probably a useful heuristic to incorporate into ones thinking. The problem is that the choice of the prototype structure can be made quite arbitrarily and still provide a 'theory' which accounts for the data. Given _any_ data pattern to be accounted for, one could devise an indefinitely large number of prototype structures plus any number of transformations to account for the data. Given this possibility, we must choose from among the possible prototypes the one which appears to be the most valid psychologically.

At this point the HAM model runs into another difficulty. One wonders whether or not the elements which comprise the associative net of HAM are the best ones to choose. Not only A&B, but probably the vast majority of researchers in the area work with 'subject' (or agent), 'object', 'verb', etc., as the psychological primitives, without acknowledging that these elements are only presumed

to exist. The fact is, we <u>do not know what the underlying elements are</u>, if any exist at all.

As alluded to in the introduction, the words which can fit each of these syntactic categories can have a variety of semantic characteristics. The results of this study show that at least one of these categories -- animacy -- significantly influences the pattern of recall. It would seem, then, that if a theory of sentence memory is to be at all adequate it must be able to accomodate the effects of the semantic characteristics of the words.

<u>The Image Construction Process: Some Speculations</u>

Once it is realized that the proper interpretive context for these data is a peripheral processing stage, then there is not much point in attempting a patchwork repair job on the HAM model. Apparently A&B paid too little attention to the characteristics of the various phenomena which they are simultaneously attempting to model with HAM. The interpretation which will now be offered attends specifically to the short term sentence memory characteristics of the experimental task.

The basis upon which this interpretation rests is provided by the subjects' accounts of how they performed in the present task. To put it simply, they generally formed an image of the relations suggested in the stimulus sentence. We will not be concerned with what an <u>image</u> is. The image-construction strategy is not presented as a general, all-

purpose encoding device. It merely seems to be the optimal procedure for the sort of short term memory task which the subjects were presented with.

We shall first summarize the basic strategy and then turn to an account of the data. Assume that in performing this memory task the subject constructs a 'scenario', or, almost literally imagines a movie set. The 'location' would be the neutral backdrop against which the action is displayed. The object, particularly if it is inanimate, would be seen as an environmental prop. Most inanimate objects are probably neutral with respect to the location they belong in. Thus, they could be easily imagined in any location, and an object-location linkage is formed.

Assume, then, that the object-location bond is the locus around which the image construction process builds. Although it would seem that imagining an agent would be logically prior to imagining the act which links it to the object, the agent-verb pair is probably integrated into the scene as a unit. Yet once we think about how one would 'imagine' an act, we can see that although the A-V unit may be integrated into the image simultaneously, this does not mean that the V is linked to the A. The question would be: is an act more easily imagined as an ongoing process or is an act imagined in terms of its consequences on the object?

Clark and Stafford (1969) show that verbs tend to be recalled in the past tense, which suggests that a verb is most easily imagined in terms of its consequences on the

object. There is a complication, however. In a proposition such as "The carpenter tore the rug" (List I, sentence 6) all else being equal, it may be easier to imagine a torn rug than a carpenter tearing. On the other hand, with "The sheriff watched the child" (List I, sentence 9) a sheriff watching seems simpler than a child watched. It would seem that verbs can differ in terms of what noun they are most closely related to.

A proper interpretation of the data will require a reevaluation of A&B's methodological postulate. The usual way in which the dependent measures are interpreted is by way of a suggestion that they indicate proximity of elements in a memory network or perhaps the strength of association between them. We must keep in mind that the subjects in the present sort of study are working under a time limit; they have eight minutes to encode 24 sentences perfectly. The suggestion is that given the above encoding strategy, the dependent measures indicate the extent to which the encoding process has progressed. High scores indicate that those components are well established; low scores indicate only partial encoding.

Given the encoding strategy and given the time constraint placed on the subject, it would follow that whatever factors aid in the quick establishment of the O-L linkage which supplies the basis for memory will allow more time for the establishment of the other words in memory, and thus improve the overall recall. The data indicates that

inanimacy of the object improves recall. The explanation, as alluded to above, is that inanimate objects are more neutral than animate-human with respect to a location they can merge with.

The principle which underlies this explanation can be called contextual accomodation, and it generalizes to most of the other results. This principle will be illustrated by considering a problem with the words chosen as agents. The A's and V's were so chosen so as to have little relation to each other, the idea being that recall based simply on common knowledge, e.g., "The sheriff arrested the thief", would not be very informative with respect to word associations in sentence memory. However, at the point of 'imagining' some A acting on some O, the animate-human characteristic is thus irrelevant to imagining the act. Any human would suffice; but to remember a specific sort of human, such as a mechanic, a larger associative context would be required to make a mechanic relevant to the act in question.

The difficulty with single sentences as stimuli is that they present a great deal of information without supplying a context which makes that information relevant. For the subject in the experiment, if he is to adequately construct an image of the sentence, he must provide his own context to make the additional information relevant. Imagining contexts places a greater demand on the entire process, and with the limited time available, the subject may not complete the

formation of his image.

This rationale holds for animate vs. inanimate objects. If animate objects require the subject to provide a meaningful context to justify that object's presence in the particular location, then the subject will take longer to get around to imagining the rest of the sentence; thus recall will be lower. Inanimate objects merge more quickly with the location; more time is available for establishing the V and A in memory, and thus recall is relatively higher.

To further illustrate this line of reasoning we shall consider the animacy x content word interaction for the probe score data. First, L is not affected by animacy, which suggests that L does in fact provide the neutral backdrop against which the image is constructed. Second, when O is animate the subject is required to engage in the time consuming process of providing a contextual explanation for the specific object. The animate O is thus not very well established and the A and V accordingly suffer. Third, when O is inanimate, it is established more quickly, thus permitting more time to be spent on establishing A and V in memory, so their performance improves. Assuming that V is imagined in terms of its effect on O, this might explain the high rise in V. Since A is animate-human it will still require additional contextual explanation by the subject. Presumably, after all the other steps in the imagining process are performed there is still not much time left to establish the A in the image.

One last example will serve to illustrate how the dependent measures are to be interpreted. It was noted that both V and A, when used as probes, elicit O more often than any other word, and that this preference was restricted entirely to the inanimate object. Contrary to the standard manner of interpretation, which would conclude that A and V are strongly <u>associated</u> to O, or worse, to an inanimate O, the interpretation offered here is simply that the inanimate O is the best established word in memory, and so is present more often to be elicited.

In the animacy x content word interaction with O as probe a similar interpretation holds. A and V are more often elicited by inanimate O simply because they are more likely to be in memory, not because they are more strongly 'linked' to O.

Concluding remarks

We have seen that the discrepancies between A&B's original data and the predictions generated from the HAM model are not artifactual but are probably due to inadequacies of HAM itself. Specifically, in failing to seriously take into account the distinction between an underlying knowledge structure and a more specific memory structure, A&B's model makes no provision for the effects of short term processing on what is recalled. Whereas it was suggested that the data from this sort of experimental paradigm cannot at present be reasonably interpreted to

support HAM as a theory of knowledge organization, the data does show that HAM, as a model of sentence memory, is inadequate. It was further suggested that any attempt to retain the specific structural characteristics of HAM while still using it as a model of sentence memory would reduce HAM to a totally arbitrary 'theory' which would do little more than restate the empirical regularities.

With respect to the speculations offered in the previous section, they should be viewed as an ideational framework within which data can be interpreted and from which a theory can eventually be derived. The important points to be retained are that first, the process by which a sentence is remembered is primarily a constructive one; second, that the 'constructive' aspect of the process is involved in building upon an interpretive context for the information in a sentence, or in supplying a relevant context if one is lacking; and third, that the data are interpreted as signifying the extent to which this process has successfully assimilated the input.

It is suggested that the details of the process, as presented in the previous section, be taken lightly until further research is done. For example, would the O-L pair always provide the locus around which the constructive process builds, or would the word most easily imagined -- whatever the word might be -- always provide the locus? An experiment where the agent is inanimate and the object is animate might aid in answering this question.

Finally, one other matter which deserves closer attention in further research of this type should be mentioned. Greater care should be taken in choosing the verbs to be used in the sentences, balancing for the extent to which a verb tends to gravitate towards either the agent or the object. This control would not be expected to alter the pattern of results from the present study, but rather would reveal additional subtleties of the relation between the verb and the agent and object.

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APPENDIX A

Summary tables for Analyses of Variance

TABLE 1: Probe score data

SOURCE	SS	df	MS	F	p
SCOPE: A	157.55	1	157.55	1.62	
VOICE: B	253.75	1	253.75	2.6	
ANIMACY: C	358.8	1	358.8	53.41	.005
CONTENT WORD: D	220.57	3	73.52	12.99	.005
AxB	19.6	1	19.6	0.2	
AxC	3.5	1	3.5	0.52	
BxC	2.0	1	2.0	0.3	
AxD	30.47	3	10.16	1.79	
BxD	48.04	3	16.01	2.83	.05
CxD	355.66	3	118.55	17.93	.005
S(AB)	5460.84	56	97.51		
AxBxC	0.05	1	0.05	0.01	
AxBxD	14.16	3	4.72	0.83	
AxCxD	9.72	3	3.24	0.49	
BxCxD	19.32	3	6.44	0.97	
SxC(AB)	376.19	56	6.72		
SxD(AB)	950.99	168	5.66		
AxBxCxD	13.57	3	4.52	0.68	
SxCD(AB)	1110.89	168	6.61		

TABLE 2: Recall score data

SOURCE	SS	df	MS	F	p
SCOPE: A	157.55	1	157.55	1.62	
VOICE: B	253.75	1	253.75	2.6	
ANIMACY: C	358.8	1	358.8	53.41	.005
CONTENT WORD: D	97.01	3	32.34	12.15	.005
AxB	19.6	1	19.6	0.2	
AxC	3.5	1	3.5	0.52	
BxC	2.0	1	2.0	0.3	
AxD	30.51	3	10.17	3.82	.05
BxD	25.27	3	8.42	3.17	.05
CxD	11.12	3	3.71	1.38	
S(AB)	5460.84	56	97.51		
AxBxC	0.05	1	0.05	0.01	
AxBxD	1.32	3	0.44	0.17	
AxCxD	0.32	3	0.11	0.04	
BxCxD	2.46	3	0.81	0.3	
SxC(AB)	376.19	56	6.72		
SxD(AB)	447.13	168	2.66		
AxBxCxD	1.77	3	0.59	0.22	
SxCD(AB)	452.59	168	2.69		

TABLE 3: Agent as probe

SOURCE	SS	df	MS	F	p
SCOPE: A	3.4	1	3.4	0.37	
VOICE: B	46.22	1	46.22	4.96	.05
ANIMACY: C	22.0	1	22.0	14.27	.005
CONTENT WORD: D	20.97	2	10.44	17.31	.005
AxB	6.67	1	6.67	0.72	
AxC	0.003	1	0.003	0.0	
BxC	0.34	1	0.34	0.22	
AxD	2.77	2	1.39	2.29	
BxD	1.52	2	0.76	1.25	
CxD	7.74	2	3.87	5.7	.005
S(AB)	521.86	56	9.32		
AxBxC	0.47	1	0.47	0.3	
AxBxD	0.54	2	0.27	0.44	
AxCxD	0.21	2	0.1	0.15	
BxCxD	0.91	2	0.45	0.67	
SxC(AB)	86.35	56	1.54		
SxD(AB)	67.86	112	0.61		
AxBxCxD	1.44	2	0.72	1.06	
SxCD(AB)	76.01	112	0.68		

TABLE 4: Object as probe

SOURCE	SS	df	MS	F	p
SCOPE: A	8.1	1	8.1	0.71	
VOICE: B	10.68	1	10.68	0.94	
ANIMACY: C	124.84	1	124.84	50.81	.005
CONTENT WORD: D	17.77	2	8.89	14.46	.005
AxB	---	1	---	0.0	
AxC	0.1	1	0.1	0.04	
BxC	1.34	1	1.34	0.55	
AxD	5.55	2	2.77	4.52	.05
BxD	8.86	2	4.44	7.22	.005
CxD	5.71	2	2.85	4.75	.05
S(AB)	636.84	56	11.37		
AxBxC	1.11	1	1.11	0.45	
AxBxD	0.32	2	0.16	0.26	
AxCxD	0.95	2	0.47	0.79	
BxCxD	0.21	2	0.1	0.17	
SxC(AB)	137.6	56	2.46		
SxD(AB)	68.81	112	0.61		
AxBxCxD	1.87	2	0.94	1.56	
SxCD(AB)	67.22	112	0.6		

TABLE 5: Verb as probe

SOURCE	SS	df	MS	F	p
SCOPE: A	38.02	1	38.02	5.43	.05
VOICE: B	39.34	1	39.34	5.61	.05
ANIMACY: C	83.14	1	83.14	35.72	.005
CONTENT WORD: D	13.27	2	6.64	11.68	.005
AxB	0.14	1	0.14	0.02	
AxC	4.23	1	4.23	1.82	
BxC	2.34	1	2.34	1.0	
AxD	3.35	2	1.67	2.95	
BxD	9.61	2	4.8	8.45	.005
CxD	8.34	2	4.17	9.04	.005
S(AB)	392.33	56	7.01		
AxBxC	1.47	1	1.47	0.63	
AxBxD	0.11	2	0.05	0.09	
AxCxD	0.02	2	0.01	0.02	
BxCxD	0.27	2	0.14	0.3	
SxC(AB)	130.33	56	2.33		
SxD(AB)	63.66	112	0.57		
AxBxCxD	1.71	2	0.85	1.85	
SxCD(AB)	51.63	112	0.46		

TABLE 6: Location as probe

SOURCE	SS	df	MS	F	p
SCOPE: A	12.84	1	12.84	1.23	
VOICE: B	4.01	1	4.01	0.38	
ANIMACY: C	9.34	1	9.34	3.7	
CONTENT WORD: D	20.6	2	10.3	21.37	.005
AxB	4.44	1	4.44	0.43	
AxC	0.04	1	0.04	0.02	
BxC	3.21	1	3.21	1.27	
AxD	0.42	2	0.21	0.44	
BxD	1.36	2	0.68	1.41	
CxD	0.09	2	0.04	0.13	
S(AB)	584.13	56	10.43		
AxBxC	1.6	1	1.6	0.63	
AxBxD	0.29	2	0.14	0.3	
AxCxD	0.02	2	0.01	0.03	
BxCxD	0.96	2	0.48	1.4	
SxC(AB)	141.46	56	2.53		
SxD(AB)	53.99	112	0.48		
AxBxCxD	---	2	---	0.0	
SxCD(AB)	38.22	112	0.34		

APPENDIX B

Criteria for constructing stimulus material.

1. The choice of words for the sentences must permit the formation of each of the four sentence types. For example:

i) The nurse in the store broke the dish.

ii) In the store the nurse broke the dish.

iii) The dish in the store was broken by the nurse.

iv) In the store the dish was broken by the nurse.

Because of this restriction, all objects used must be singular, since an object in the plural would result in a passive sentence of the form "...the dishes <u>were</u> broken by..."

2. The prepositional phrase is always of the form "in the ________ ".

3. No content word will be used more than once.

4. All the 'agent' words will be animate-human, designating some human activity or characteristic, e.g., lawyer, immigrant, thief, woman.

5. One half of the 'object' words will be animate-human and one half of them will be inanimate, e.g., desk, flask, wiring.

6. General rules for word combinations:

a) Avoid colloquial or cliche expressions.

b) Avoid alliteration; e.g., The doctor damaged

the desk.

c) Avoid obvious associations. For example: Doctors do not do anything to or with nurses, interns, or medicine. Nor do they do anything in hospitals. Similarly, lawyers do not interact with convicts or judges, nor are they to be found in courtrooms.

d) Avoid the overly unusual or semantically bizarre.

7. In the construction of the lists of sentences, make an attempt to distribute topic groups (doctor, nurse, orderly, hospital, etc.) equally between the lists.

Sentence List 1

1. The gardener in the shed removed the wiring.
2. The shopper in the truck played the guitar.
3. The dilettante in the airplane rebuked the orderly.
4. The nurse in the store broke the dish.
5. The waiter in the library frightened the preacher.
6. The carpenter in the hotel tore the rug.
7. The drifter in the tavern met the singer.
8. The hippie in the arena jumped the fence.
9. The sheriff in the car watched the child.
10. The officer in the garage burned the invoice.
11. The butler in the studio avoided the senator.
12. The pianist in the newsroom followed the quarterback.

13. The diplomat in the bakery polished the flask.
14. The fugitive in the station discovered the valise.
15. The storekeeper in the courtroom beguiled the receptionist.
16. The intern in the garrison painted the door.
17. The pilot in the stadium abducted the mayor.
18. The agent in the garden sold the chair.
19. The student in the kitchen fought the caretaker.
20. The reporter in the pharmacy flustered the ballerina.
21. The editor in the ghetto lost the overcoat.
22. The lawyer in the courtyard scratched the desk.
23. The farmer in the forest rescued the soldier.
24. The playboy in the lobby damaged the pottery.

<u>Sentence List 2</u>

1. The escort in the hut greeted the watchman.
2. The banker in the restaurant ate the steak.
3. The critic in the pavilion weighed the dancer.
4. The prostitute in the hospital called the mechanic.
5. The attendant in the office heard the conversation.
6. The doctor in the street caught the ball.
7. The doorman in the greenhouse washed the knife.
8. The novice in the theatre hid the medicine.
9. The woman in the warehouse bought the suit.
10. The orator in the alley injured the newsboy.
11. The professor in the dormitory calmed the engineer.

12. The foreigner in the brewery described the painting.

13. The tourist in the casino found the ticket.

14. The immigrant in the factory detained the emissary.

15. The labourer in the park saw the actor.

16. The lodger in the forge annoyed the husband.

17. The sailor in the basement fixed the leak.

18. The manager in the elevator hit the drummer.

19. The clown in the plaza kissed the matron.

20. The thief in the playground teased the fireman.

21. The foreman in the barn repaired the washer.

22. The president in the corridor embarrassed the technician.

23. The devotee in the cemetary evaded the private.

24. The salesman in the cafe struck the table.